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PSYCHOPHYSICAL MEASUREMENT METHODS

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Blondel and Rey (1) raise the question as to the dependence of the threshold for light stimuli on the intensity and duration of the stimulus. They come to the conclusion that Bloch's law which makes the threshold depend on the quantity of illumination (the product of optical energy times duration) holds for stimuli of comparatively high intensity only. The following argument is of considerable theoretical interest to psychophysics. Ribière made experiments on the distance inside of which a light of given intensity but variable duration could be seen. It was found that this distance increased constantly with duration of the light stimulus between the limits 0.25 to 1.78 seconds without attaining the distance at which a constant light could be seen. From this it follows that the so-called minimum stimulation is well defined only with reference to a certain duration. The absolute minimum stimulation would be the one produced by a liminal stimulus after an infinite duration.

Wm. Brown (2) undertook to write a short text-book for the use of the student of quantitative psychology, which is a wider field than psychophysical investigation. The first chapter contains a presentation of the methods, which is perhaps a little short but presents the methods of constant stimuli and of just perceptible differences in some detail. The reader will be pleased to find a new idea. Brown proposes to apply Pearson's theory of the curves of distribution to the study of psychometric functions. The difficulties of this promising enterprise are by no means small, but they may be overcome.

P. Desroche (3) made observations on the influence of the distance of a constant source of light on the phototropic reactions of *Chlamydomonas Steinii*. The animals were first attracted to one side of a drop by a light placed at a certain distance, and then the drop was turned by 180° so as to attract the animals to the other side. The speed of this movement was determined. In the study of the influence of the distance of the light on the speed, one has to distinguish two cases. If several hundred of these animals are placed in the drop the distance of the light influences their speed in a way closely resembling the law of Fechner. If a single animal is experimented on, one finds that its speed is uniform and does not depend on the distance of the light. If, however, the distance of the light increases, the animal does not move straight towards the light and it indulges in frequent stops. Desroche believes that the similarity of his results with the law of Fechner is the result of the compound influence of the individual movements of the animals which become more irregular the greater the distance of the light.

R. Dodge (4) raises the question whether introspective facts are the only mental reality, or whether there are other real indicators of mental life. Rejecting the first view he welcomes every fact, no matter whether its source is pathology, neurology, introspection, or the observation of animal behavior, as long as it is capable of throwing some light on human psychology. There are certain facts like fatigue, or mental work, which are not accessible to introspection, but which are nevertheless as valid indications of mental facts as any result of introspection. Experimental evidence that certain mental capacities undergo measurable objective changes is as true a psychological fact as anything discovered by introspection. Introspection is a real and important factor in certain fields of work, but is only one among many.

Chas. Henry (5) attempts to apply mathematical methods to the general problems of biology, an enterprise for which he is doubly qualified as the author of a text-book on mathematics, and the director of a physiological laboratory. His problem is to study sensitivity and muscular irritability as dependent on the intensity and duration of the stimulus. He studies particularly the sensations of light produced by a variable optical energy of constant duration and those produced by constant energy of variable duration. He tries to determine the character of this dependence and finds that it is identical with the so-called photographic function, which gives the amount of silver reduced by a variable intensity of light of constant duration. It is likely that the curve of photographic action also gives

the process of nervous excitation produced by a variable optical energy of constant duration. Only a certain part of this curve, however, corresponds to conscious processes; the rest of it, from a certain point of inflection on, represents the course of nervous excitation not accompanied by mental processes. The entire curve is called the psychophysical curve, and the author believes that its nature very likely remains the same for different kinds of sense perception. From this one would have to conclude that the processes produced by different stimulations resemble each other to a high degree.

Studying the excitation of the muscle the author assumes that it is directly proportional to the duration of the effort. The dependence of these two quantities can be expressed in a myophysical law and can be studied by the self-registering ergograph for the total work. The curves obtained in this way closely resemble the curve of sensations. The author then proceeds to show that the form of the functions for the irritability of the senses and the muscles do not differ much from those for the change in the weight of cells placed in a medium where the products of dissimilation accumulate, provided that assimilation diminishes in the course of time. These considerations show the possibility of connecting the psychophysical and myophysical laws with those of physical chemistry and of finding the principles of a general mathematical theory of irritability.

The second part of the book is very curious. The author assumes a certain general principle from which he deduces the laws for the variations in the apparent size of straight lines and the wave-lengths of complementary colors. Short mention is made of my demonstration that the arithmetic mean of a group of observations is the most probable value if these observations are made systematically.

E. Jacobson (**6**) studied the interference of qualitatively different stimuli. The technique of this kind of experiments is not very well developed and its methodology is still untouched by modern refinements. The author did not feel called upon to comply with the requirements of psychophysical experimentation, and the outcome is that there is hardly one result in his paper that would stand a thorough test.

P. Lasareff (**7**) studies the influence of the size of the visual field on the threshold of sensations. He represents his results by the formula of Helmholtz who modified the psychophysical formula of Fechner by taking into consideration the illumination of the retina.

W. Reimer (**8**) studied the history of the notion of intensity with special reference to the applications which this notion has found in

psychology. This historical sketch, however, does not include the most recent researches in this field.

F. H. Safford (9) took up the rather technical question as to the number of decimal places to be retained in the numbers of relative frequency and in the coefficients of the equation of the psychometric functions set up by Lagrange's formula. He concludes that the relative frequencies in my monograph on statistical methods should be cut to three instead of four decimal places, and that the number of figures retained by me in Lagrange's formula is entirely too large. He also criticizes my expression of treating the data without a definite hypothesis about the psychometric functions.

Sanford's variation of the method of just perceptible differences is dealt with in (10). There exists some diversity of opinion as to the real value and significance of this variation. It is shown that it does not change the final outcome of this method and that it has the character of a precaution in so far as it enables us to discover gross mistakes.

My paper (11) is a reply to (9). It is pointed out that Lagrange's formula is merely an artificial construction for the representation of the data of observations, and the coefficients in the equation set up by this formula have no immediate physical significance. If a smaller number of figures is retained in the calculation of the coefficients, the equation does not represent the empirical data at all and becomes useless. The phrase "treating the data without a definite hypothesis on the psychometric functions" merely implies that the hypothesis used for the purpose of computation is so indifferent that one could not possibly mistake it for a final solution of the problem.

A further paper (12) is of indirect importance for the problems of psychophysics. A new definition of the notions of chance and probability is given which is based on the modern theory of classes. It is shown that the notion of logical chance, that is, the relation between the general and the particular, is the only one used for defining the notion of mathematical probability. The calculus of probabilities does not make use of events which are not causally necessitated. This is shown by several examples of events which are the objects of the calculus of probabilities in spite of the fact that there does not exist any doubt as to the causes which necessitate them. The demonstration is carried as far as the deduction of the two fundamental propositions of the calculus of probabilities (the theorem of addition and the theorem of multiplication), because all the

remaining propositions can be deduced from these two by purely logical processes. Psychophysics makes very wide use of the notion of probability in so far as the method of just perceptible differences as well as the method of constant stimuli are built up on this notion. The passing of a judgment under well-defined conditions is regarded as a chance event, and the question naturally arises whether we should favor the idea of these events not being fully determined by their antecedent causes, or whether we should form an idea about them which is more in agreement with the principles of physical science. The paper shows that the use of the calculus of probabilities does not deny the causal connections between events and it is, therefore, advisable to favor the view that the passing of a judgment is an event causally fully determined in spite of the fact that we are at present unable to follow up these connections.

C. A. Willis and the present writer (13) worked out some experimental data on lifted weights. The results show the influence of variations of the standard stimulus on the constants of the psychometric functions. The standard stimuli of 100, 125, 150, 175, 200, 225 grammes were compared with appropriate comparison weights, and the results worked out by the method of constant stimuli. It was found that the constant h decreased constantly with increasing intensity of the comparison stimulus, while c remains more or less constant. These results are in agreement with those obtained in working out the data of acoumetric experiments. No well-pronounced regularity corresponding to the so-called law of Weber was found.

W. Wirth's *Psychophysik* (14) is doubtlessly the most significant publication of the year. The book is divided into two parts, the first of which contains the mathematical methods, and the second the experimental arrangements used in psychophysical investigations. It is not possible to give a full statement of the contents of this book, and we shall call attention to two significant facts only. The first is that Wirth defines psychophysics so as to let it comprise all the methods of experimental psychology. In this sense one may say that the book contains a new program for psychophysical investigation, and it cannot be doubted that the majority of workers in this field will welcome this new definition of psychophysics. The next observation refers to Wirth's treatment of the so-called psychophysical methods. He recognizes one genuine psychophysical method only, namely, the one based on the notion of the psychometric functions, the theory of which he himself has cultivated with great success. The old methods of psychophysical measurement are mentioned on

account of their historical interest and because they frequently enable one to find a rough and ready result, the exact determination of which would require a considerable amount of work. We lastly mention as significant the fact that the book appeared as part of a text-book on the methods of physiology, thereby procuring to psychophysics the standing of a recognized auxiliary science of physiology.[1]

Wirth's paper (15) contains a criticism of the present writer's treatment of the method of just perceptible differences and of G. F. Lipp's use of the equality judgments. He emphasizes the hypothetical nature of the threshold, and insists that it cannot be defined in terms of the result of the method of just perceptible differences. He furthermore tries to show that the result of the method of just perceptible differences does not coincide with that of the method of constant stimuli unless one introduces some special hypothesis in regard to the nature of the psychometric functions. The appendix of the paper contains an interesting discussion of one of the series of my experiments on lifted weights. He calculates the arithmetical means of the limits and of their standard deviations in groups of 50 experiments, and tries to show that a definite effect of practice can be found in these results. It would not seem very surprising that such an influence of practice should have taken place, but it is doubtful whether Wirth's numbers definitely establish the existence of this factor.

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[1] See special review on p. 245, below.

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TESTS

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The field of tests has broadened out so that it now includes several types of investigation which do not in all cases closely resemble one another. The first group of investigations which may be regarded as being included in this topic deal with the development of methods of testing single mental processes. The purpose of these investigations is to determine the best method of procedure to be followed. There have thus far been published under the direction of the Committee on Tests of the American Psychological Association reports by Angell (**2**) upon Mental Imagery; by Pillsbury (**29**) on Tests of the Intensity of Sound; by Seashore (**31**) on Pitch Discrimination; by Woodworth and Wells (**42**) on Association; and by Yerkes and Watson (**43**) on Vision in Animals.

Angell describes the methods which have been used to test imagery, classifying them into objective and subjective methods. The objective methods in general, which exclude introspection, are held to be unreliable as methods of determining the type of mental imagery. The author chooses the tests which he has found to be most reliable and forms two series, adding suggestions regarding the grading of the results. Pillsbury criticises in detail the methods for testing intensity of sound, and selects the telephone as the one to be most highly recommended from the point of view of accuracy, but recommends the tuning fork from the point of view of convenience. Seashore not only recommends the most reliable apparatus for testing pitch discrimination, but also goes into some detail in giving directions for the conduct of the tests and interpretation of the results, and discusses their practical application. Woodworth and

Wells have made an elaborate study of methods of testing association, for the purpose not so much of comparing the various methods which are in use as of working out a standard method of each type of testing, and of describing the methods in sufficient detail so that they may be followed by other investigators. Yerkes and Watson give a very detailed description of the methods and apparatus which are used for testing the light and color vision, and the size, form, and distance perception in animals, and recommend the most reliable forms. A short article by Kirkpatrick (20) consists mainly in the criticism of the Betts test for the vividness of imagery. The study of Whitley (40) was undertaken for the purpose of investigating the reliability of certain of the Columbia tests of simple mental processes, and other tests which are added to these. As a result of the investigation, certain of the tests were found to be more reliable than others and were selected for recommendation. The investigation concludes with a study of the practice curve.

The second group of tests to be considered deals with single mental processes or groups of the mental processes for the purpose of determining their value as a means of diagnosis. The diagnosis may be of general capacity or general ability or of mental derangement or retardation, or of some special condition such as fatigue.

Healy and Fernald (17) have collected a series of tests which they have found useful in diagnosing the mental capacity of children in the Juvenile Court. The same tests are applied to the children of all ages, and are for the purpose not of rating the children quantitatively, but of classifying them into one of a number of groups, such as superior mental ability, average mental ability, dull, etc. The aim in choosing the tests was so far as possible to bring out the capacity of the child for dealing with practical situations of life rather than for meeting the demand of the school room.

Another group of tests has been tried out by Abelson (1) upon a group of backward children, of a mean age of 11. The tests dealt partly with simple motor or perceptual processes and partly with higher mental processes. The author found that the tests on the whole correlated well with the teacher's estimates, but that a single test taken alone was not reliable. The tests of higher mental processes did not seem to be better than the tests of the simpler processes.

Descoeudres (11) investigated various tests upon a very small group of fourteen backward children. The main purpose was to compare the reliability of the different tests used, and this was done

by finding the correlation between the rank of the children in each individual test, and in the average of all the tests together. The author concluded that tests of reasoning were the best, tests of imagination next, and tests of attention and memory of the least value.

In order to determine whether certain criticisms which have been made of the value of the teacher's estimate are well founded, Gilby (15) and Waite (38) compared the order in which school children are placed in the estimate of the teacher, and the order in which they are placed by their grades on examination or in their class work. On the basis of the correlation which was found between these two methods of ranking, both investigators concluded that the teacher's estimate of the children was as reliable as their school grades. A comparison of the results of testing memory, and the ability to apprehend abstract relations by giving opposites to such words as "but" and "although" with the rank in class in logic and psychology was made by Marvin (24). The author found that there was a correlation between the standing in class and in the tests, and that the correlation between memory and psychology was somewhat closer than that between memory and logic.

Immediate memory was used as a test of fatigue in school children by Winch (41). He investigated the relative improvement in mechanical memory which was made by a group of children who were tested in the morning, and a parallel group tested in the afternoon. The average difference was found to be small, amounting to 2 per cent. in one case and to 5 per cent. in the other. The result may be interpreted as indicating either that immediate memory is not a good test for fatigue, or that there was not much fatigue present in the case of these children.

The use of Kraepelin's reckoning test in psychiatry is recommended in the article by Maloney (22). The author describes the test and the manner in which it may be used for the purpose of diagnosing mental derangement.

The same general purpose which underlies the tests of the preceding group underlies also another group of tests, which are arranged in series of ascending difficulty. The series may contain tests which correspond to the different ages as do the Binet tests, or may merely be arranged in groups as are the De Sanctis tests.

The Binet tests have received much attention during the past year, and have been subjected to many experiments. These experiments have been described for the most part in the article by Huey

(19). It will not be worth while to duplicate either his reviews or his bibliography. The reader is therefore referred to Huey's article for the literature upon the Binet tests. A few articles that Huey has not referred to may be mentioned.

Descoeudres (12) has attempted to determine how accurately the Binet scale distinguishes bright from dull pupils, and how uniform it is throughout its range. The 1908 series was used. The tests were applied to two bright and two dull pupils (each pair consisting of a boy and a girl) from each of six classes, the ages ranging from 7½ to 13 years. The author found that of all the correct responses which were made the bright pupils made 57 per cent. and the dull pupils 43 per cent. Some of the tests, however, distinguished the bright from the dull pupils much better than others. The author agrees with the other investigators who have used the Binet scale, that the tests for the early years are too easy, and the tests for the later years too difficult. Gifford and Goddard (14) used the Binet scale in the examination of defective children in the Juvenile Court, and found more or less mental retardation in every case but one out of 100 children. Hill and Goddard (18) tested fifty delinquent girls by means of the Binet scale and concluded that all but four were mentally defective. McDonald (21) says in a communication that he regards the Binet scale as of value in testing senile dementia, paresis and moral imbecility.

An article by De Sanctis (10) discusses the theoretical basis for test series and reproduces his own scale, which has been described elsewhere by Goddard and Whipple. De Sanctis distinguishes two levels of mental processes, the level of lower and higher ideation. Development proceeds from one level of intelligence to another, and hence series of tests may be devised to determine the level of experience or the maturity of individuals. De Sanctis does not accept the hypothesis, however, that intellectual defect in defective children and dements corresponds "to the degrees of intellectual development in the ages of growth."

An entirely different type of test has to do with accomplishment rather than with native ability, and seeks to measure the result of educational effort. One form of test of this sort consists in standardized tests in particular school subjects. Pearson (28) describes a method by which the results of work in spelling may be scientifically tested. His method, however, is not standardized in the sense that the results found by different investigators may be compared. Courtis (9) describes briefly his elaborately standardized tests in

arithmetic and discusses the need of such tests for purposes of comparison and of guidance in teaching. Courtis (8) gives in another article illustrations of tests in writing, arithmetic, spelling, history and English in order to show the value and possibility of standardized tests. Bliss (6) describes a method, which he has used for some years, of testing deficiency in English teaching by means of the "reproduction story." A story, according to this method, is read to the pupils, which they are then required to reproduce. Though not permitting of strictly comparable results on account of the lack of a standardized method of grading, the author believes the test to be of value as an aid in supervision.

Thorndike (35, 36) describes the method of construction of a scale which is intended to serve as a means for grading in English composition. The purpose is to make comparable grading of compositions by different persons and in different places, and to enable the investigator to determine not merely the relative rank of different specimens, but also the amount of difference in excellence between them.

Ayers (3) describes the derivation of a scale for the measurement of the legibility of handwriting and submits the scale which was constructed on a basis of the investigation. The scale was constructed upon the basis of the time taken by ten investigators to read a large number of samples of writing of school children. Freeman (13) describes the procedure by which the teacher or supervisor may test the legibility and speed of writing in order to obtain standardized results.

School and college grades may also be regarded as tests. Smith (32) and Steele (33) urge the adoption of systems of grading which are based upon the normal distribution of traits. Steele suggests that teachers be led to see the importance of a rational system by a demonstration of the lack of uniformity in their own marking, and gives an illustration of the means by which this may be done.

Strayer (34), Ayers (4), and Thorndike (37) discuss in general the importance of quantitative measurements of the results of educational effort. Gulick (16) discusses the same topic in relation to school hygiene.

Another purpose for which tests are employed is the characterization of an individual in order to determine his relationship to other individuals or to a norm in respect to his general mental type. Margis (23) describes various more or less unsatisfactory methods by which this determination may be made—the intuitive-descriptive method,

the classification method, etc.,—and describes in some detail the analytic method as advocated by Stern and employed in the Institut für Angewandte Psychologie and Psychologische Sammelforschung. This method consists of a thorough investigation of the individual by means of a carefully worked out questionnaire.

Münsterberg (**26**) discusses with some illustrations the use of tests in vocational guidance, and Seashore (**30**) describes an elaborate method for determining the qualification for singing possessed by an individual.

The theoretical principles which underlie mental tests are discussed by Betz (**5**) and Brown (**7**). Both of these authors treat at some length the mathematical principles by which correlation may be determined and give particular attention to the work of Galton, Pearson and Spearman in this connection. They also discuss critically the investigations which have been carried on and the methods which are employed. Betz concludes that it is futile to attempt to determine general intelligence, but holds that the mental processes are more specialized than such a concept would assume. Brown concludes by describing the results of his investigations into the correlation of various mental processes. He concludes that certain tests, as that of Ebbinghaus, correlate better with general intelligence than others, but that there is much less correlation between processes which we regard as similar than we should expect.

Weiss (**39**) suggests a new method of ranking individuals by comparing the performance of the various members of a group with the average performance of the group. The method in short is to determine the deviation of a particular individual from the mean of the group to which he belongs.

Myers (**27**) in a critical article points out the dangers of the unsuccessful use of mental tests, or of hasty and ill-advised conclusions drawn from their interpretation.

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CORRELATION

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The publication during 1911–12 of many important papers on correlation, its interpretation, methods and applications, affords an unusual opportunity to introduce a general review on this topic. Contributions by Pearson, Hart and Spearman, and Winch, if they stand the test of criticism, will remain fundamental in this field. Betz with his monograph *Über Korrelation* (4) publishes a bibliography of 102 titles, most of which are dated within the last ten years. He presents a complete and critical treatment of the subject, devoting chapters to the methods for determining correlation, the correlation investigations of psychological problems, the recent publications of the Galton Eugenics Laboratory and the correlation work done upon ability in mathematics. In the chapter on methods, besides explaining Pearson's fundamental product-moment formula he gives Sheppard's formula for correction of σ if the distribution is not symmetrical. He also devotes sections to non-linear correlations, the probable errors of the coefficients, correlations by rank, the four-fold method,

multiple correlation, Spearman's correction formulæ, and spurious correlation, giving briefly the standard treatments of each of these topics. The criticism of Spearman's correction formula by Pearson and Brown is reviewed and approved. It is contended that the assumption that the errors of observation in the different series are not correlated does not hold in specific cases, Brown claiming .66 correlation in one case. It should not be expected to hold under the usual experimental conditions. This difficulty is not avoided in Spearman's modification of his formula. Furthermore Betz believes that it is not clear whether Spearman would not eliminate gross true fluctuations of activity along with slight chance errors of observation.

The high coefficients in sensory discrimination obtained by Spearman are more likely to show the ease in which the different children followed the instructions. The evidence of a central factor is not convincing. The "hierarchical" ordering of abilities might be produced by a general cause of error. The evidence at present is against a general pronounced, easily apparent intelligence. Were it not for our prejudice, we should be surprised that the correlations of intellectual activities are so high rather than that they are not higher.

The eugenics researches are most important indirectly to psychology in forming a general point of view because they show that factors like alcohol and housing which were thought to be of enormous importance are found to be of minimal effect. This is at present determined for only a few characteristics but it is very conceivable that it holds generally.

In conclusion Betz emphasizes that correlation alone does not demonstrate a functional connection. Moreover, if changing one variable necessarily changes the second it is not shown that the converse is true; not all functional connections are reversible. An inventory of correlations cannot disclose psychological secrets unless supplemented by an understanding of mental facts. Correlations serve two purposes in psychology: (1) mass-studies, in which traits are described in popular terms, to aid in the educational or social description of groups; (2) the discovery of functional connections by using the greatest care in analysis and experiment with small groups. In another brief paper (5) Betz shows with actual examples how to prepare a correlation table, compute the product-moment coefficient, the correlation ratio and test for linearity.

Pearson (20) grasps and sets forth correlation and contingency in their ultimate significance. His wider outlook regards the universe

as "a complex of contingent, not causally linked phenomena." "The aim of science ceases to be the discovery of 'cause' and 'effect'; in order to predict future experience it seeks out the phenomena which are most highly correlated. . . . From this standpoint it finds no distinction in kind but only in degree between the data, method of treatment, or the resulting 'laws' of chemical, physical, biological, or sociological investigations. . . . No phenomena are causal; all phenomena are contingent, and the problem before us is to measure the degree of this contingency, which we have seen lies between the *zero* of independence and the unity of causation." Pearson is to be thanked for clearly showing how easy it is and how useful to science to conceive causation as a specific limited form of contingency. For understanding the assumptions underlying the correlation ratio and the coefficient of contingency this new chapter is the clearest brief statement to be found anywhere. Students of correlation will undoubtedly get much joy out of the statement of this leader that a contingency table is "the numerical syllogism of observational science, which replaces for all its purposes the barren syllogism of the old Aristotelian logic. We do not say, 'Some B is A,' but we state numerically how much of each class of B is associated with each category of A." Pearson promises that much is to be added to the chapters on living forms when these appear in Part II. of the new edition.

Pearson (**21**) derives a formula for determining whether small values of the correlation ratio are significant. He also contributes further (**22**) to the discussion of the Law of Ancestral Heredity and reiterates his former conclusions that "the theory of multiple correlation is the natural manner in which to approach the theory of ancestral inheritance." "The fact that Mendelian gametic correlations approach in some respects those found by observation on populations, is not a justification of Mendelism."

An astonishing paper on the interpretation of psychological correlations, if we may accept its basic presupposition, is that which has appeared very recently under the joint authorship of Spearman and Hart (**15**). The article claims to demonstrate conclusively by means of a correlation criterion which they propose as crucial that "correlation arises through performances, however different, depending partly on a 'General Common Factor.'" They offer also a new interpretation of this source of correlation which in one form or another has been the favorite explanation of Spearman for some time. This view, called "unifocal," they contrast with the "non-focal"

view of universal independence of mental processes drawn from Thorndike's earlier writings, and Thorndike's later view of levels as well as those other "multifocal" interpretations which attribute correlation to correspondence of type or faculty. "Every performance depends, not only on this General Factor, but also in varying degree on a factor specific to itself and all very similar performances." The General Factor is not any special sort of process, such as "intelligence" or "synthetic power," nor is it to be identified with attention. It is "some common fund of energy," characterized on the mental side as "intellective energy." On the physiological side every intellectual act involves "both the specific activity of a particular system of cortical neurons, and also the general energy of the whole cortex." Every such performance, therefore, inhibits quite different simultaneous ones, any kind of non-mechanical process competes for this fund of energy. As evidence of this conception the authors point to "the larger correlations usually produced by the operations demanding attention, the reduction of correlation as the performances tend to become mechanical, and the large correlations shown by even the simplest performances of the mentally defective." The recent "surprising regeneration of 'mental tests'" they attribute to "both their purpose and method having been transformed in accordance with the theory of a General Factor."

The proposed correlation criterion which the authors suggest as the conclusive mathematical test of their "unifocal" theory is too complex to set forth here. The authors believe that it is decidedly better than the "hierarchy" of coefficients heretofore used. Applying this criterion to the results of fourteen different series of correlation experiments by men of all the different faiths, they find the surprising result that in every case the correlations are $+.73$ or over and the median almost complete $+1.00$, the value demanded by their theory and as far as possible from the values of 0 and -1.00 which they contend is demanded by the other theories. They also use their criterion to controvert Brown's criticism of their "hierarchical" arrangements of coefficients. The paper disclaims any opposition to Thorndike's work on specific abilities, the correlations of which may be superposed upon correlations of a more general character. "Still less is it in opposition to his work on 'formal training.' . . . Variation of training, within normal limits, appears to have no appreciable influence on the General Factor, but only on the specific ones." Spearman (**24**) presents a new form of his correction formula for eliminating chance errors of observation, which had been published

also in the *Brit. J. of Psychol.*, 1910, 3, 271–295. It is based on dividing the measurements of each individual into two or more groups in such a way that the average of each group may be considered alike except for these chance observational variations. Spearman (25) also replies to the criticism of Brown and Betz concerning his former correction formulæ. He contends that only computation can determine how far chance errors are to be guarded against. The careful arrangement of the research, which his critics advise, is insufficient. Brown's mathematical and empirical criticisms, he claims, are both faulty. Betz (6) answers this reply of Spearman and remains unconvinced about the usefulness to psychology of Spearman's formulæ for eliminating accidental errors.

Abelson's research (1), carried out under the direction of Spearman, afforded part of the data on which the interpretation of the General Factor was based. Nine specially devised tests were tried on 88 girls and 43 boys from London schools for defectives, 10–12 of each sex of the highest grade pupils in each of eight schools. The coefficients were computed by Spearman's "foot-rule" method for the boys and girls separately in each school and then averaged. The tests were repeated two or more times until a reliability of .70 or more was reached. Tables give the intercorrelations of each test with the others and with the average of the others. Corrections for differences in age and for chance errors he has calculated in part and estimates that they will not affect his conclusions. The tests may be regarded "as almost independent and about equally accurate measurements of 'general ability.'" On this assumption Spearman devised formulæ for estimating how much any number of tests pooled together will differ from the result of an infinite number of tests pooled. Pooling tests very greatly increases their trustworthiness in estimating "general ability." The correlation between all the tests pooled together and estimates of "practical intelligence" was .60 for the girls and .56 for the boys.

In a paper outlined before the joint meeting of the British Psychological Society, the Mind Association, and the Aristotelian Society, Winch (29) with hesitation sets forth a "modified faculty doctrine," which is based mainly on determining the functions thus to be regarded as associated by discovering their correlations and measuring the transfer of training under improved methods. He emphasizes especially his method of "steadying" a group by repeating the tests until succeeding tests correlate highly. This should be done before one kind of test is correlated with another. It is to be remembered,

however, that "high correlation sets us a problem of connection. It does not *ipso facto* enable us to conclude that a relation of interdependence exists." Low correlation between traits measured for groups of individuals may even go with functional connection of the two traits in the same individual. "Brown's capacity may be big in one direction and small in another *as compared with that of Smith and Robinson*, but an alteration in one of his functions may produce some alteration in the other. To find the connection of functions within the same mind, would it not be best to get a number of measures for the same individual and correlate these?" In determining whether training of one function transfers, we should use his method of "equal groups," chosen after "steadying." "The mental functions thus connected will, I believe, give 'groupings' or 'faculties' rather unlike those of early psychology." In order to justify formal training "we should need to show that, by the formal training of function α we can produce a transferred improvement in function β which we could not, with equal work, produce by training function β itself," or that "that function may not be accessible to direct attack."

Woodworth (30) introduces a new quick method of computing r which he believes is "worthy to be regarded as one of the best abridged or 'foot-rule' methods." He also develops simplified formulæ for computing r, the average correlation within any number of tests, and for the Spearman correction for attenuation, when the original measurements have been reduced to terms of the standard or the average deviation. He advocates this method of reduction whenever several tests on the same individuals are either to be combined or correlated. It is the only way to preserve the refinement of the original measurements. The reduction of the measurements also allows one to show the success of each individual in relation to the tests taken as a whole. With nine tests for logical relationships applied to thirteen individuals, he finds that those who ranked high were more consistent than those who ranked low. The Pearson coefficient between standing and consistence was .72. He suggests that the standard variability of the average standing of the individuals is a new measure of the agreement of several tests which has certain advantages over the Av. r. Woodworth and Wells (31) utilize the method of correlating the average standing of each subject with his standing in each test, after reducing the tests to equivalence, and thus determine the relative value of certain association tests.

Yule (32) gives us a text-book on statistics which devotes eight

chapters to association and correlation methods and is adapted to those who have a limited knowledge of mathematics. Written primarily for students of economics and vital statistics, it aims also to be of use to biologists and others. The text is the most comprehensive simple treatment of correlation to be found. Two of the formulæ suggested in the text—the Coefficient of Association and the Correction Coefficient for a two- × two-fold table are emphatically attacked by Heron (16) both as to their derivation and the results obtained by their use. Stern (26) devotes a chapter to the statistical methods of correlation and two other brief chapters to the concept of correlation and the aims of research in this line. Brown's book on *Mental Measurement* (8) is written primarily for the psychologist, who will find it perhaps, the handiest manual of the recent correlation formulæ. It follows Pearson closely.[1]

In two researches the teacher's estimate of intelligence is empirically defended from Yule's belief "that unless they are very carefully controlled, the teacher's judgments are *relatively* as well as absolutely valueless." Gilby's study (14) is authoritatively prepared with the assistance of Pearson. The judgments of 36 teachers in eight schools on 1,725 boys in which they graded intelligence on the scale of five categories defined by Pearson, it traced in interrelations with order in examination, percentage of marks, age, standard, school, and clothing, the latter defined in five grades. Correlation of general intelligence and order in examination for constant age and constant standard was .671. The places in marks and examination were settled by headmasters independently of the class teachers. The correlation between clothing and intelligence for constant age and constant standard is .22. "There can we think be little doubt that the evidence of clothing is roughly a measure of home conditions." There is very little relation between age and order in class or age and intelligence. The other research by Waite (27) presents similar results. "No single psychological test or complex of tests is in the least likely to replace our present method of judging general efficiency for public or other service." The correlation between age and intelligence in the same "form" is either negligible or negative. In both papers the work is very carefully done from the statistical point of view, full correlation tables are given, various methods tried, and linearity estimated.

Correlation has been used extensively by Whitley (28) as a method for evaluating various tests for similar functions and for determining

[1] See special review in this BULLETIN, 1912, 9, 125–126.

the relationship of various scores for tests involving practice. About 45 different tests were repeated on from three to seven subjects and occasionally checked by a larger group. The tests, grouped around each of six types (association, memory, perception, discrimination, discrimination and motor, motor), were each correlated with the average records in that group, the test showing the highest correlation being regarded as the best representative of that type, although it might be less valuable from other points of view. In the second part of the study perhaps the most striking result is the high negative correlation between the position at the start and either gross or percentile gain with practice. Five of the ten coefficients are over −.90. "Individuals with low standing can and do improve the most, judging objectively." The relationship of the position at the start with the average of the whole series is closer than between it and the position at the finish. "Fewer tests each administered oftener would give a truer estimate of an individual and a better basis for comparison and correlation." "The criticism that giving only a few trials measures not the mental process supposedly tested but merely adaptability to strange conditions such as apparatus, instructions, working for speed, and the particular requirements of the test is seldom of weight."

The first published results of the Anthropometric Laboratory at Oxford (**23**) include 16 physical measurements and one mental test, McDougall's spot pattern. Twenty correlations are given for the physical measurements for each of the ages from 18 to 22, with 95 to 330 cases at the different ages. The table is thus the most complete for any of the college data on the subject. The correlations between the possession of a scholarship or exhibition and the spot pattern test which McDougall thinks measures concentration is small, .22 on the average for all grade groups, and about the same for this test and "class in final schools."

In a preliminary report of an important study to be published by the Bureau of Education Baldwin (**2**), as the result of successive measurements on the same group of 350 boys and 435 girls taken for periods of from 3 to 11½ years indicates that there are different correlations for growth in height and weight for those above the median than for those below. Those above begin and end their various periods of acceleration and retardation earlier. Curves for 52 individuals show that correlations in weight do not follow those for height in detail.

Boyce (**7**) correlates the estimates of 27 superintendents and

principals as to the rank of their high school teachers in various traits bearing on teaching efficiency, and finds that general merit had little or no relation to sex, to general appearance .36, to instructional skill .90, to stimulation of pupils .85, to stimulation of individuals .85. These three, with intellectual capacity .71 and discipline .67, are the qualities deemed most important. Descoeudres (11) gives correlations between 15 tests (six taken from the Binet series) and her estimate of intelligence for 14 deficient children from 6 to 14 years. For the separate tests the coefficients run from .509 to .878. The correlation with the average rank in all is .991. No correction was made for differences in age. Norsworthy (19) finds the correlations of the rate of learning German-English word associations with immediate memory to be .41 and with memory after 30 days to be .50; between immediate and this later memory .60. The tests were on 83 college students and disprove the theory of "easy come, easy go," at least for this group. Lobsein (17) and Erler (12) get opposed results on the problem whether memory for numbers correlates with ability in the simple arithmetical operations. Busemann's and Bell's aims are shown in the title of their papers (9) and (3). Lipmann's paper (18) is a review of that field. Cohn and Dieffenbacher's correlation results (10) are probably affected by neglect of age differences in their groups. Forsyth (13) found slight correlation between ages and grades with college students.

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REACTION TIMES

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The studies of the year have been concerned with questions of technique and the effect of direction of attention on reaction time. Breitwieser (1) attacks again the old problem of sensory and motor reactions. Eleven subjects gave an average excess of sensory reaction time to auditory stimuli over motor reaction time of 18σ, the excess ranging from 8.9σ to 44σ. Series were then obtained from two trained subjects without instructions as to direction of attention. Sensory, motor, and normal reactions were introspectively noted and the number reported as motor or sensory was about equal. The times were the same as when the attitudes were voluntarily assumed. In reactions with artificial direction of attention the attempt was made to devise an objective method of insuring the type of attention, motor by varying the resistance of the key, sensory by variation in the clang character of the auditory stimuli. The times for the "induced" sensory and the voluntary sensory reactions are about the same. The times for the induced motor and the voluntary motor are very different and the attitudes in the two cases are different. The voluntary motor reaction involves merely the preparation to react, the voluntary sensory reaction involves both the preparation to observe and to react, the interference between the two adjustments being reflected in the lengthened time for sensory reactions.

Breitwieser next applied the reaction time method to a study of fluctuations of attention, by varying from one to ten seconds the intervals between the ready signal and the stimulus. The results with eighteen subjects, contrary to those reported by Della Valle, showed no rhythmic variations. The number of reactions with each subject is too small and the variability too great for the effects to be shown with any reliability. The most favorable interval for auditory stimuli is apparently 2–3 secs. and for visual stimuli 3–4 secs. Detailed studies with two trained subjects showed considerable regularity as to favorable and unfavorable intervals, but there was no evidence of rhythmic fluctuations in the reaction times.

The last chapter is concerned with the effect of varying the resistance of the reacting key. The times are lengthened progressively as the resistance is increased, hence the necessity of indicating the resistance of the key when the downward pressure type of move-

ment is used. The time of reaction with the release type of movement is independent of the resistance. The excess of force expended varies independently of the resistance and tends to decrease with practice.

The purpose of Grassi's (3) experiments was to determine the effect of change in the direction of attention on sensory reactions to tactual stimuli of constant intensity. Comparisons were made between reactions (1) when the area stimulated is constant, (2) when the area is varied with each stimulation—points on the left side of the body, face, forearm, leg and back—(3) when the area is varied periodically, after from seven to fourteen reactions with a constant area. The experimenter found considerable variation, curiously enough, in reaction times from day to day and from forenoon to afternoon, so that comparisons between reactions with constant stimulus points and the "transition" reactions, with which the study is mainly concerned, are based on reactions made at one sitting. The rather unusual diurnal variations do not appear to be a matter of practice. However, the experiments are chiefly on one subject and no measure of variability is given. The variability appears to be too great for the results to have much significance. The most important point of the study is the comparison, in the series with periodic variation in the points stimulated, between the reactions with constant stimulus points and the "transition" reactions. The "transition" reactions are longer by from 14σ to 55σ, depending on whether the transition is made from one area to another or from one point to another point within the same area.

Günther (4) reëxamines in detail the processes of reaction in recording stellar transits and the differences between reactions to sudden stimuli and reactions to transits. In reactions to transits the conditions in the fore-period between the emergence of the stimulus into the field of vision and the transit give rise to two forms of reaction, the anticipating and the complete. Just as in reactions to rhythmic stimuli the reactions come to coincide in time with the stimulus, so in recording transits the observer tends to anticipate the stimulus. The effect of such anticipation and its relation to methods of registration are now under investigation in the Leipzig laboratory. Günther's problem is the complete reaction and the conditions affecting it. Even in the complete reaction sensory and motor attitudes complicate the problem. The motor reaction tends to become anticipating or at any rate there is no real apperception of the stimulus preceding the reaction. In reactions to transits it is peculiarly difficult to resist the tendency to premature and abbre-

viated reactions and they are likely to become ultimately anticipating reactions. Introspective testimony as to the nature of the reaction is unreliable and some objective control is necessary. This was done by conducting practice experiments where the stimulus—artificial star on a kymograph—was arrested just before it reached the meridian. Such series were continued until the proper adjustment of attention was developed and were repeated at intervals to insure the maintenance of the attitude.

Experiments were made with five subjects and with six rates of movement of the stimulus, 3, 1.5, 1, .75, .37, .19 cm. per second. The average reaction times for these rates are 216σ, 204σ, 205σ, 209σ, 225σ, and 249σ respectively. That the attitude in the complete reaction can be developed and maintained is shown by the close agreement in the length of the times by the different subjects and by the uniformity of the distribution about the mode, which is greater than that shown in Alechsieff's results. It is shown also in the relatively slight influence of variations in rates of transits. Contrary to Alechsieff, Günther recommends the complete reaction as the best and most reliable method in recording transit observations, on the ground that the adjustment of attention is more readily controlled and that individual differences are less in evidence.

Dunlap (**2**) finds that a source of error in time measurements with the Hipp chronoscope, due to the effects of use and temperature on the armature spring, may be eliminated by removing the spring and making the necessary readjustments in the counterpoise and circuit arrangements. For the technical details reference must be made to the original article.

Marie and Nachmann (**6**) describe briefly the arrangement for measuring with the d'Arsonval chronometer reaction times to visual stimuli—seven colored lights—and to olfactory stimuli—odorous liquids. The arrangement for olfactory stimuli is ingenious.

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APPARATUS

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Crehore and Meara (1) describe an instrument which records the microscopic movements of a diaphragm by means of light interference. It works on the principle of the tambour, and the record is made by means of interference bands obtained by a mercury vapor lamp. The registration may be made by direct reading or by a photograph. The instrument seems to be capable of exceedingly fine and accurate registration. The article contains a number of illustrations, the records of physiological events showing the registration of sound waves, including those from the human voice.

Dunlap (2) gives a report of a careful experimental investigation of the errors in the fall-hammer, the reliability of the break spark in chronoscopic records, the latency of the magnetic markers, the effect of the reversal of the current in the Hipp chronoscope, and other features. Suggestions are made for improvements in these instruments.

Ponzo (3) describes a new two-point æsthesiometer, which is designed to secure simultaneous and equal pressure of the two points, and furnishes a convenient means of adjusting the distance. It may be obtained from E. Zimmermann, Leipzig, Germany.

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REPORT OF MEETING

THE CLARK MEETING OF EXPERIMENTAL PSYCHOLOGISTS

The ninth annual meeting of experimental psychologists took place in the Psychological Laboratory of Clark University, Monday–Wednesday, April 15–17. Twenty-four experimental psychologists were present representing the laboratories of Columbia, Cornell, Clark, Dartmouth, Harvard, Hobart, Pennsylvania, Princeton, Wesleyan, and Yale.

The program of Monday afternoon consisted of two papers on Inhibition, the first presented by Dr. H. S. Langfeld (Harvard), and the second by Dr. E. Jacobson. Dr. Langfeld reported upon further investigations into the nature of the negative attitude and the act of suppression. Two methods of experimentation were employed. The one, which consisted in guiding a stylus down the groove of a modified Whipple tracing board, was used to determine what processes are involved in the suppression of movement. Series of trials were made both under positive instruction, *i. e.*, to go down the center, and under negative instruction, *i. e.*, not to touch the sides. As yet there have been too few trials to permit of deductions from the quantitative results, but the introspection in some instances showed imagery corresponding to a negative attitude. It was also found that when the left hand was used, it was more difficult to hold the instruction in mind. The other method was to instruct the subject to recite the alphabet or the numbers from one to thirty omitting certain letters or numbers. In the fore-period visual and auditory imagery predominated. The negative was generally expressed solely in the auditory image of the instruction, but instances of visual imagery of the negative were discovered. In the main-period the words to be suppressed appeared in consciousness at times as auditory-kinæsthetic imagery. In several cases, however, introspection found no trace of these words. Dr. Jacobson reported three series of experiments on Inhibition, which were carried out at Cornell University. In the first the effect of strong sound sensations on simultaneous odors was tested. The results were negative. On the supposition that these negative results might be due to added

effort of attention to the odors in order to overcome the distraction, passive and effortless attention was cultivated. The figures showed some difference from those of the first series, indicating that the abandonment of effort had had some effect, but, in general, inhibitions still failed to appear. Finally, the observers were trained to give strongest attention to the sound, and it was then found that the intensity of the odor sensations was markedly diminished. Many introspective analyses were made of inhibition and attention. The meeting then adjourned to the home of President and Mrs. Sanford who entertained at tea. Later in the afternoon Professor J. P. Porter exhibited a trained dog whose behavior is under investigation.

The evening session was devoted to reports of investigations in progress in various laboratories. The reports from the laboratories of Teachers College and Columbia were given by Professor E. L. Thorndike, of Harvard by Dr. H. S. Langfeld, of Pennsylvania by Professor F. M. Urban, of Princeton by Professor H. C. Warren, of Wesleyan by Professor R. Dodge, and of Yale by Dr. E. P. Frost. Both the reports and the discussions which followed were informal.

The session of Tuesday morning was opened by Mr. C. A. Ruckmich (Cornell), who discussed the History and Status of Psychology in America. Dr. L. R. Geissler (Physical Laboratory, National Electric Lamp Association) read a paper on The Introspective Study of Mental Functions. A systematic functional psychology, he said, has yet to work out its own methods and terminology. Its subject-matter may be divided into (*a*) *extrinsic relations*, existing between mental and non-mental facts and including the cognitive, adaptive, and organic relations of mind to its corresponding physical, biological, and physiological determinants; (*b*) *intrinsic relations*, occurring between attributes of the same mental process, or between simultaneous and successive processes, or between individual processes and mind as a whole; and (*c*) mental *activities*, considered as structural changes in consciousness viewed in the light of the completed mental product or result accomplished. Introspection seems adequate to the problems under (*b*), but may require supplementary methods such as biological reflection, neurological and pathological observations, systematic study of human and animal behavior, etc., for the problems under (*a*) and (*c*). A confusion of the structural and functional aspects of mind may perhaps account for the recent controversies over imageless thought, relational elements, and the distinction between mental act and content. Mr. K. M. Dallenbach (Cornell) followed with a paper on Blindfold Chess Playing. The final paper of

the morning was presented by Professor Dodge, who reported the results of an investigation on mental work. Three students were required to write examination papers of various degrees of difficulty, and a record of the rate of heart-beat was obtained by a device which successfully registered the heart-rate, yet at the same time permitted bodily movements on the part of the observer. Mental work is believed to be physical work, and the rate of heart-beat is taken to be a reliable indicator of the degree of mental work.

The afternoon session was devoted to a general discussion of the experimental investigation of thought: methods, results, applications. The discussion was introduced by Professor Titchener who was followed by President Hall, Dr. Geissler, Professor Dodge, Professor Urban, President Sanford, Professor Warren, Dr. Jacobson, Professor Thorndike and Professor Baird. Professor Titchener then summarized the discussion.

The evening session was held at the home of President G. Stanley Hall. Professor J. P. Porter read a paper reporting an investigation by Professor B. N. Gates (Mass. Agricultural College) on Color Discrimination in Bees. Yellow, white, and crimson paper flowers were used, and it was found that the bees went to the flowers even when they were sealed in glass tubes and when they were reflected in a mirror. Although brightness was not altogether eliminated, the results so far appear to be positive. Further experiments are contemplated. Dr. Geissler gave an informal report of the laboratory maintained by the National Electric Lamp Association, and of the several investigations in the psychology of light and vision which are in progress under his direction. The remainder of the evening was given over to the enjoyment of the hospitality extended by President Hall.

The concluding session of the meeting was held on Wednesday morning, when reports were heard from the Clark, Cornell, and Dartmouth laboratories. Mr. J. M. Fletcher, Mr. E. O. Finkenbinder, and Dr. H. P. Weld reported on investigations which are practically completed, and Professor Baird reported on investigations in progress in the laboratory of Clark University. Professor W. V. Bingham gave an account of the work at Dartmouth and Mr. C. A. Ruchmich and Professor Titchener reported on the investigations in progress in the undergraduate and graduate laboratories, respectively, at Cornell.

It was agreed to hold the tenth annual meeting at Wesleyan University.

H. P. Weld

Clark University

SPECIAL REVIEWS

PHYSIOLOGICAL AND EXPERIMENTAL TEXTS

Elements of Physiological Psychology. GEORGE TRUMBULL LADD and ROBERT SESSIONS WOODWORTH. New York: Charles Scribner's Sons, 1911. Pp. xix + 704.

Ladd's *Elements of Physiological Psychology* was first published in 1887. For many years it has served as the standard reference work in English on physiological and experimental psychology and its influence on the development of the science in this country has undoubtedly been very great. Many of the younger psychologists got their first introduction to and interest in the experimental study of mental processes through its pages and to them a new edition will be especially welcome.

The extensiveness of the revision which the book has undergone at the hands of the author and Professor Woodworth and which was found necessary in order to make it adequately representative of the present status of the science, is a striking testimony to the vigor with which research has been carried on in psychology and its most closely related sciences during the intervening twenty-four years. To incorporate the wealth of material that has accumulated, every chapter has been rewritten and new chapters have been added. The changes in data, in the arrangement for systematic presentation, and the shiftings of emphasis are so great that one who wishes to compare in detail the treatment in the two editions has difficulty in finding his way about.

The general plan of the new volume is the same as that of the earlier edition. In details of logical arrangement the new edition is superior to the old. Part I. gives a lucid exposition in 292 pages of the development, anatomy, chemistry, and physiology of the nervous system. This part opens with two new chapters on The Place of the Nervous System in the Animal Kingdom and on The Development of the Nervous System in the Individual. These chapters strike the reviewer as the best in the entire book and as most likely to be widely used by students of psychology. The clearness of the presentation of the typical stages in the evolution of the nervous system from the amœba to man, and of the growth of the nervous system in embryonic

life and childhood is an evidence of the skill of the writers in exposition and an impressive indication of the progress of neurological research. The substantial gains to our knowledge in these fields make possible precision of statement and detail in description that are noteworthy. This is especially shown by a comparison of Chapter VI. in the old edition on the development of the nervous system with the corresponding chapter in the new edition. They are so radically different that the latter may fairly be called new.

The succeeding chapters on the gross and minute anatomy of the nervous system incorporate goodly portions from the first edition with the inevitable result that repetition and references back to the earlier chapters occur with great frequency. Thirty-seven figures, for the most part new, richly illustrate and illumine the text. The chemistry of the nervous system is briefly treated in a special chapter, and two chapters are given to nervous conduction and the reflex functions.

The chapter on the end-organs, or receptors, of the nervous system is the only rather disappointing chapter in Part I. It has undergone less change than any other. The psychologist would surely hope to find in a book of this character a full and adequate discussion of the anatomy and physiology of the sense-organs. One is inclined to regret the space given to the gross anatomy, and particularly the 59 pages given to the metaphysics of the relation of mind and body, when one reads the sections on the muscle sense, the effects of light on the retina, the semicircular canals, and the end organs of motion.

The two chapters on the cerebral hemispheres and the localization of cerebral functions have been transferred to Part I., where they logically belong. Many admirably selected illustrations of localization and of the histological structure of the cortex accompany a remarkably clear and critical review of the complex and conflicting literature on cerebral physiology. These two chapters alone make the book a necessary addition to the psychologist's library.

Part II. summarizes in 328 pages the main results of the qualitative and quantitative experimental study of sensation, perception, memory, thought, feeling, movement, and the time-relations of mental phenomena, and the correlations of mental processes with nervous processes. While this part does not purport to review the whole field of experimental psychology, it is nevertheless perhaps the best general treatment we have. In the main the substance and arrangement of the chapters on the quality and quantity of sensations, presentations of sense, and reaction time are unchanged. Practically

every section has been rewritten and such additional data as are at hand have been added. It is a gratifying evidence of scientific productivity in this country to find that these data can be drawn as largely as they are from investigations by American students.

The application of experimental methods to the feelings and to the higher mental processes has necessitated three practically new chapters, the first on feeling, emotion, and expressive movement, including also a brief discussion of fatigue; a second on memory and the process of learning, which reviews not only the results of the experimental study of memory and the acquistion of skill in man but also learning processes in lower animals; and a third on the mechanism of thought, including a brief discussion of attention. The chapter on memory and learning is especially valuable.

The chapters in this part are not of equal completeness and value. While twenty-nine pages are given to reaction time, undoubtedly the best summary of the literature obtainable, seven pages each to fatigue and attention do not, of course, adequately represent the relative amounts of experimental works in these fields. It is perhaps ungracious, however, to mention such a point when one reflects upon the labor already involved in canvassing and critically evaluating a literature which covers practically the whole field of experimentation in psychology, and in preparing a compendium of facts which puts every psychologist under a debt of gratitude to the authors.

Part III., abridged in the new edition to 59 pages, treats of the Nature of Mind and the metaphysical conception of the relation of mind and body to which the results of physiological psychology point. This part could have been omitted without great loss, and the space devoted to a fuller discussion of physiological and experimental problems. The closing chapter of Part I. and sections 14–34 in the last chapter of Part II. set forth clearly the limits of present scientific knowledge concerning psychophysical correlations. They hardly furnish evidence either for or against the "common-sense" dualism, which is maintained, and the discussion of the problem might well have been left to philosophy to which in the Preface it is relegated.

The "controlling purpose" of the book is to present an adequate summary of "what modern science knows, or reasonably conjectures, about the correlations existing between the nervous mechanism and the mental life of man." The erudition of the authors, combined with a keen critical judgment and exceptional skill in presentation, leads to a realization of this purpose in a high degree. The book is

again one that the student of physiological and experimental psychology cannot well be without.

V. A. C. HENMON

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A Text-Book of Experimental Psychology with Laboratory Exercises. CHARLES S. MYERS. Second Edition. Cambridge: The University Press; New York: Longmans, Green, and Co., 1911. *Part I., Text-Book.* Pp. xiv + 344. *Part II., Laboratory Exercises.* Pp. v + 107.

The author tells us in his preface that the work has been thoroughly revised. It is now published in two volumes, the laboratory exercises being bound separately from the text-book. This is in some respects an advantage. It is, however, regrettable that the text-book cannot be obtained separately if so desired.

The recent work of Dr. H. Head, especially the material of the Croonian Lectures[1] has inspired most of the important changes and additions. It is interesting to note the influence of these physiological investigations.

In the paragraph on The Two Systems of Cutaneous Sensibility, which has been partially rewritten, Myers says (p. 13) that there is no evidence, at present, that two separate systems of peripheral nerve fibers correspond to the two systems of cutaneous sensibility. In the first edition, we were told that the work of Head and his collaborators compel us to assume the existence of these two systems. The title of Chapter XVI. has been changed from "On Weight" to "Muscular Effort" and the last part upon effort (pp. 213–217), which is now called an experience and not a "sense," has been partially rewritten and enlarged. The efferent impulses influence our perceptions. For example, they are responsible for the displacements in localization in case of paralysis of the eye muscles. There is no necessity to adopt the hypothesis that the motor impulse is directed toward some cortical sensory center. It is probable that volitional movements effect a disturbance in various systems of unconscious dispositions which Head calls "schemata" upon which is based our awareness of spatial relations. Not only, however, does Myers assume an effect of volition upon unconscious dispositions, but also a consciousness of the effort, which he describes as "the 'act' that is inherent in every conative experience." This latter assump-

[1] These lectures appeared in the 34th volume of *Brain* and not in the 33d volume, as Myers undoubtedly thought they would.

tion is not clearly stated here, but the reference to Ach's experiments on page 332 more fully explains it.

In the paragraph on the Histological Basis of the Spatial Threshold it is stated (p. 223) that the spatial threshold may be impaired in regions where tactual sensibility is normal. This is due to the fact that the impulses concerned with spatial discrimination do not cross until they reach the medulla oblongata, while the impulses concerned with tactual sensibility cross already in the cord. In the paragraph on Relative and Absolute Localization on the Skin, we learn (p. 224) that, due to a similar difference in the place of crossing of the impulses, localization may be present with an absence of kinæsthesis, although normally kinæsthesis aids localization. Before describing Lotze's and Hering's theory of local signs M. says (p. 225): "Introspection and the study of abnormal states show that the ability to distinguish a double from a single touch is something different from the ability to ascribe to the two touches definite and different localizations."

At the beginning of the chapter On Sensibility and Sensory Acuity, we find that lesions of the sensory cortex destroy the power of discrimination and thus affect sensory acuity, and the chapter on Identity and Difference begins with a paragraph on The Influence of the Sensory Cortex.

At the end of Chapter XXIV. (p. 313) there is an interesting description of the effect of thalamic lesion on feeling. The most significant change is a decided increase in the amount of pleasure or displeasure produced by a given sensation.

Among the other changes and additions, we note (p. 33) a description of the vowel quality of pure tones as discovered in the recent investigations of W. Köhler. In the paragraph on Theories of Consonants, reference is made to Liebermann and Révész's article "Ueber Orthosymphonie" (pp. 54 and 55).

In discussing adequate and inadequate stimuli (p. 111), electrical stimuli have been omitted from the list of inadequate stimuli for pain, heat, cold, or pressure.

In the chapter on Size and Direction, it is stated (pp. 282–283) that, although a perception of distance does not consciously affect that of size, yet, primarily, size must depend on distance. An appeal is made to unconscious dispositions as a possible explanation of the relation of apparent distance to the apparent size of objects.

Presumably in consideration of the work in the Cornell laboratory on attention, the doubt expressed as to the possibility of measuring attention, which ended the chapter on that function in the first edition, has now been omitted.

An additional chapter on Thought and Volition has been added. It seems to the reviewer that the book would be better without it, the more in that it does not fit into the general scheme of the book, there being no experiment in the second volume corresponding to this chapter. It is vague in its descriptions and contains statements which are bound to give the student a distorted idea of the present situation in regard to the question of imageless thought. Surely a search through the literature will fail to find "a general agreement that in addition to the objects thought of, in addition to feelings, there is a specific act of thinking, which is totally devoid of sensory content" (p. 327), nor can the view that "there can be no doubt that among the more cultured, especially among those who are practiced in abstract thinking, imageless thought is very common" (p. 327) be entertained by a number of psychologists whom the author would undoubtedly place in this favored class. The description of the genesis of the experience of awareness of meaning is difficult to follow. "Doubtless in the development of species, meaning is prior to thought. In the development of the individual, thought is doubtless prior to language; infants being capable of rudimentary thought before they have acquired internal speech. It is therefore not surprising that imagery, which plays so important a part in the mental life of children and in that of adults who encourage its use, may yet fall away under certain conditions and in certain individuals, leaving recognizable only what can be expressed as 'awareness' of meaning." If meaning is prior to imageless thought, is not this statement against rather than for his theory? We are also told that usually there is no difficulty in separating the content of thought from the act of thinking. The part of the chapter on volition follows closely the experiments of Ach.

In Part II., the experimental portion, the experiment on the after-sensations of tones is omitted. The experiment on The Distinction between Cutaneous and Motor Sensations is also omitted and two experiments upon the labyrinthine sensations substituted. A brief description of experiments on testimony has been added to the experiment on association reactions.

The book is very solidly written and, in most instances, a rare discrimination has been used in the selection of the important facts of psychology. It remains one of the best text-books we have and it is, therefore, more the pity that the author is not as clear in his exposition as he is thorough in his thought. So many facts are contained in so small a space, that the connecting links have had to be

omitted and the reader is compelled to fill in between the lines. This makes it very difficult reading for the beginner and robs the book of much of its usefulness.

HERBERT SIDNEY LANGFELD

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Psychophysik. Darstellung der Methoden der experimentellen Psychologie. W. WIRTH. (R. Tigerstedt's *Handbuch der physiologischen Methodik.* Vol. 3, Abt. 5.) Leipzig, 1912. Pp. 522.

The scope of this book is similar to that of Titchener's *Quantitative Manual* or of G. E. Müller's *Gesichtspunkte*, in so far as it aims at a presentation of the present status of psychophysics. It differs radically from its predecessors in that historical discussions and controversies are almost totally absent. The reason seems to be that psychophysics has found its bearings since the publication of the *Manual* and that most of its problems are beyond the controversial state. Titchener (loc. cit., p. 174) quotes Lipps as expressing the desirability of finding a new foundation for the psychophysical measurement methods, but Wirth has no doubt as to this point and his book shows clearly that psychophysics reaches as far as the field of experimental psychology, a view already expressed by the reviewer on several occasions.

Experimental psychology is a part of general psychology and though finding its immediate material within individual consciousness only, it is to be defined as the study of consciousness in general. In such a study one has to consider all the phenomena of the organism connected with the changes of consciousness. Constant progress in scientific observation can be obtained only by applying the experimental method. A psychological experiment does not make introspection superfluous, but gives it objectivity, because the experiences of different people under the same conditions can thus be observed. Furthermore, introspection may aid in securing the correct performance of the experiments, the subject actively coöperating in assuming and maintaining not only a certain position of the body, but also a certain "inner adjustment" essential for the outcome of the results. On the other hand, the objective data furnish the means of controlling introspection.

The general purpose of psychological experimentation is to find relations between psychical events so as to link them with the general causal connection of phenomena. The ideal of such a mutual dependence is its expression in the form of a mathematical function.

It is not indispensable for this purpose that both cause and effect be measurable, but the expression of such regularities is much simplified if one or both can be expressed quantitatively.

Most experimental investigations deal with sensations, and the problem arises to represent sensation as function of the stimulus. Every functional relation which we have found may be used for the purpose of indirect measurement, which has the formal character of a relation between purely physical quantities but which really is a symptom of a psychological relationship. Such relations are of special interest, because they show the mind in relation to the objects which surround us and thereby show the basis for the purposeful adaptation of our will reactions.

All measurements are affected by errors and the most exact physical determinations are no exception to this rule. Psychology differs in this respect only gradually from the more favored sciences. These errors are due to the fact that every event depends not only on its known causes alone but also on an indefinite number of influences which escape our notice and our control. A repetition of the measurement of a quantity implies the supposition that this uncontrollable complex of causes has remained constant. These variations are very large in the biological sciences which deal with processes subject to many strong influences, and for this reason it is necessary to treat the data of observation according to the rules of the theory of distributions (*Kollektivmasslehre*). The variations of the results in human psychology do not seem to be quite as large as those of animal psychology, because the voluntary control by the introspection of the subject eliminates some sources of variability.

Wirth explains the principles of the theory of distributions and gives the formulæ for the direct treatment of the results, for the application of the formula of Gauss and of the series of Bruns. In his treatment of the theory of psychophysical measurement the method of constant stimuli and its generalizations stand in the foreground of the interest, as is seen from the large amount of space given to the discussion of this method and its problems. We call particular attention to the formulæ for the direct treatment, some of which are of Wirth's own invention and bid fair to be of great practical use.[1]

Wirth gives the weights of the observation equations in the method of constant stimuli, calculated by my formula as well as by those of Müller. W. Brown in his book on *Mental Measurement* does the same without giving any reasons, while Wirth's suggestion that

[1] Cf. *Arch. f. d. ges. Psychol.*, **20**, 1911, pp. 1–8 of the Literaturbericht.

Müller's solution is especially simple is obviously wrong. It seems curious that both authors should have overlooked the fact that both formulæ cannot be correct.

In a complete presentation of the theory of distributions, Pearson's views ought not to have been omitted. It is true that they have not been applied to psychology until now, but practically the same remark may be made in regard to the series of Bruns. There may be some doubt as to whether this lack of success of Bruns and Pearson is due to the inherent difficulties of their methods, or to certain deficiencies of their presentation. Pearson's papers are not easy reading and Bruns's book is such that it ought to be given to senior wranglers only. The second edition of Czuber's textbook of the calculus of probabilities has made Bruns's views a little more accessible, but psychologists will be grateful to Wirth for his trouble in presenting the theory and practice of the series of Bruns.

It is not possible to give here even a brief survey of the rich experimental material embodied in this book. We merely mention presentations of the methods for studying attention, memory, time perception, feelings, and voluntary reactions. Some of the investigations, as, *e. g.*, those on the influence of sounds of different pitch on attention, or the one on the decimal equation, have not been reported before, and there are only few chapters where Wirth cannot refer to his own investigations. The general purpose of the investigation, however, remains the same everywhere: the goal is to arrive at as exact an understanding of the mental processes as possible; the psychophysical methods are the most indispensable tools for this purpose, but they are not more than tools.

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A NOTE ON APPARATUS

A Simple Blind for the Eyes. An inexpensive type of motoring-goggles (procurable at five-and-ten-cent stores for ten cents) is in use in the laboratory as a blindfold for light and dark adaptation. For the latter purpose, a heavy black paper is inserted in the eye-pieces and kept in place by means of a steel wire spring bent to fit the inside of the eye-piece. This has proved to be a very satisfactory way of excluding light stimuli of even the greatest degree of intensity. For light adaptation, the pieces of black paper are replaced with a set of translucent discs cut from architect's paper. Finally, in experi-

ments upon color-adaptation, the goggles furnish a convenient substitution for the ordinary colored glasses. In this case, gelatin papers of various colors are available for insertion in the eye-pieces. Since the goggles cover virtually the whole field of vision, they afford an excellent opportunity for producing general as well as local adaptation to color.

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